Guidelines for automated preschool vision screening: A 10-year, evidence-based update

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SUMMARY In 2003 the American Association for Pediatric Ophthalmology and Strabismus Vision Screening Committee proposed criteria for automated preschool vision screening. Recent literature from epidemiologic and natural history studies, randomized controlled trials of amblyopia treatment, and field studies of screening technologies have been reviewed for the purpose of updating these criteria. The prevalence of amblyopia risk factors (ARF) is greater than previously suspected; many young children with low-magnitude ARFs do not develop amblyopia, and those who do often respond to spectacles alone. High-magnitude ARFs increase the likelihood of amblyopia. Although depth increases with age, amblyopia remains treatable until 60 months, with decline in treatment effectiveness after age 5. US Preventive Services Task Force Preventative Services Task Force guidelines allow photoscreening for children older than 36 months of age. Some technologies directly detect amblyopia rather than ARFs. Age-based criteria for ARF detection using photoscreening is prudent: referral criteria for such instruments should produce high specificity for ARF detection in young children and high sensitivity to detect amblyopia in older children. Refractive screening for ARFs for children aged 12-30 months should detect astigmatism >2.0 D, hyperopia >4.5 D, and anisometropia >2.5 D; for children aged 31-48 months, astigmatism >2.0 D, hyperopia > 4.0 D, and anisometropia >2.0 D. For children >49 months of age original criteria should be used: astigmatism >1.5 D, anisometropia>1.5 D, and hyperopia >3.5 D. Visually significant media opacities and manifest (not intermittent) strabismus should be detected at all ages. Instruments that detect amblyopia should report results using amblyopia presence as the gold standard. These new American Association for Pediatric Ophthalmology and Strabismus Vision Screening Committee guidelines will improve reporting of results and comparison of technologies. (J AAPOS 2013;17:4-8)

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Approximately two decades ago, the first automated device for preschool vision screening became commercially available. Although this was clearly a major breakthrough, attempts to compare data from various validation studies proved difficult because there was no consensus for delineating which pathology this technology should detect or how the results of validation studies should be reported. In 2003 the Vision Screening Committee of the American Association for Pediatric Ophthalmology and Strabismus (AAPOS) established guidelines for the reporting of results from studies of automated vision screening instruments.[1] Because these technologies were designed to identify children with strabismus, anisometropia, and/or bilateral high magnitude refractive error, the published guidelines primarily addressed the magnitude of refractive error that was (by consensus) thought to put a child at risk for the development of amblyopia—the "amblyogenic factors", now called "amblyopia risk factors" (ARFs).[2]

Since the publication of these guidelines, more data have become available about the prevalence of amblyopia risk

factors in young children, the age-dependent development of amblyopia in patients with amblyopia risk factors, and the treatment of amblyopia with spectacles prior to the initiation of active occlusion or penalization treatment. The results of these studies have necessitated reassessment of these guidelines. Likewise, technology has advanced, and screening instruments are now available that detect abnormalities other than amblyopia risk factors. The purpose of this article is to review the new evidence and adjust the reporting guidelines appropriately. Although the new guidelines remain consensus-based, the evidence supporting the new guidelines is significantly stronger than the evidence that supported the 2003 guidelines.

Several prospective population-based studies have confirmed that the prevalence of amblyopia in childhood is approximately 2%,[3-5] a finding that is consistent with previous reports. However, the prevalence of ARFs is much greater than previously thought, probably in the neighborhood of 15% to 20%.[6-8] Hence, it is clear that the majority of children with amblyopia risk factors do not develop amblyopia, and this has been confirmed in a longitudinal follow-up study of children identified through vision screening.[9] If the detection of decreased vision and amblyopia are the goals of screening, then referrals based on technology that detects risk factors will result in overreferrals. It is therefore imperative that updated guidelines for detecting amblyopia risk factors propose levels that best separate those children who are most at risk for developing amblyopia from those who are not.

The relationship between refractive error and the likelihood of development of amblyopia is complex and depends on the age of the child, the magnitude of refractive blur, and other factors. For children up to 3 years of age with anisometropia, the prevalence of amblyopia appears to correlate with the magnitude of the anisometropia.[10] For those more than 3 years of age, however, the prevalence of amblyopia remains relatively constant, but the depth of amblyopia increases with age, and greater-magnitude refractive errors seem solely to increase the depth but not the prevalence of amblyopia.[11] Our updated guidelines lower the referral rate for young children by raising the threshold referral values. We recognize that this will produce a corresponding decrease in sensitivity to detect low-magnitude refractive pathology (and probably mild amblyopia) but anticipate that it will minimally affect the sensitivity to detect those high-magnitude refractive errors that are potentially most likely to lead to amblyopia. Because the prevalence of amblyopia increases with the magnitude of anisometropic refractive error,[11] authors are urged to report multiple levels of sensitivity for several magnitudes of refractive error above the thresholds proposed here.[12]

Recommendations with respect to screening of preschool children must also occur within the context of treatment using "refractive adaptation." Many children, especially those having mild amblyopia, often have marked improvement (and sometimes even resolution) of their amblyopia with spectacle treatment alone; this phenomenon is seen in children with anisometropic amblyopia[13] as well as in those with strabismic amblyopia.[14] However, refractive adaptation is less likely to occur (or be complete) in children with deeper amblyopia; thus these children must be identified at a younger age.[13] This and the aforementioned data with respect to the nature of amblyopia development in at-risk children suggest that preschool vision screening devices should aim to detect only the greatest-magnitude anisometropia at young ages, prior to when amblyopia develops and becomes entrenched. A corollary is that refractive screening technologies should have high specificity but low sensitivity to detect low-magnitude symmetric refractive errors in the youngest children.

Although detection of amblyopia at a younger age generally produces better treatment outcomes, new meta-analyses have demonstrated that amblyopia treatment does not begin to decrease in effectiveness until approximately age 5 years.[15] However, early detection of high-magnitude refractive error may allow prevention of amblyopia in some at-risk children and allow for treatment using refractive adaptation rather than active therapies at an age when amblyopia has not yet become entrenched. Also, earlier detection may allow for treatment to be more cost effective by reducing the number of medical visits required for resolution.

Amblyopia screening should be viewed as a continuous process that occurs throughout visual development, beginning in infancy. We anticipate that vision screening of children will take place at several times during the formative years rather than at one particular age; thus a high sensitivity to detect mild amblyopia during a single screening is an unnecessarily expensive strategy if it is associated with a low positive predictive value. It is noteworthy that the US Preventative Services Task Force (USPSTF) now actively recommends vision screening at least once for children between 36 months and 5 years and specifically mentions photoscreening as an appropriate screening technology.[16] Although USPSTF guidelines consider the evidence in favor of screening children aged 12-35 months to be "insufficient," the invited commentary[17] addresses this controversy and provides evidence to the contrary.

Older children (≥5 years of age) have less time available for treatment and may already have entrenched amblyopia. Thus, screening should be more sensitive in this age group. Preference should be given to visual acuity measurement that uses crowded or surrounded optotypes (LEA symbols, HOTV chart, or Sloan), with monocular testing assured by patching, which allows the direct detection of impaired visual function. However, refractive error screening is also appropriate for those children who cannot cooperate with traditional screening, for high-volume field-based screening, and for primary care settings in which traditional screening is either more challenging or less efficient than automated screening (Sloan letters are preferred both for screening and validation, but we recognize that most providers use Snellen letters).

The original AAPOS guidelines were vague with respect to the detection of strabismus, especially with respect to incomitant (paretic, restrictive, and pattern) syndromes. Intermittent exotropia and well-controlled deviations (eg, Superior Oblique Palsy, Monocular Elevation Deficiency, Duane syndrome, and Brown syndrome) are neither typically associated with amblyopia development nor with rapid loss of stereopsis; thus, they need not be detected by modalities that seek to detect decreased binocular (refractive) or monocular (amblyopia) visual acuity (such as photoscreening or direct acuity testing). However, accommodative esotropia (a manifest strabismus on an accommodative target at distance or near at any time during a formal eye examination) is associated with amblyopia development and degradation of stereopsis and should be detected even though in its early stages it may be intermittent.

The guidelines also are updated with respect to media opacities, pupillary abnormalities, and eyelid abnormalities. Any media opacity greater than 1 mm in size is potentially amblyopiogenic and should be detected with photorefractive screening. Isolated anisocoria does not produce amblyopia and its association with ocular or systemic pathology is exceedingly rare; hence it has been removed from the list of amblyopia risk factors. Finally, because nearly all amblyopia-related ptosis occurs in the setting of superimposed anisometropia,[18,19] ptosis has been removed as an ARF.

Recommendations

The following recommendations are summarized in Table 1.

1. Detection of Amblyopia Risk Factors in Toddlers (Age Group: 12-30 Months)

For very young preverbal children, the detection of low-level refractive amblyopia risk factors should be highly specific (ie, there should be very few false-positive referrals). The recommended target refractive magnitudes for detection are as follows: astigmatism >2.0 D, hyperopia >4.5 D, and anisometropia >2.5 D. These targets are set at a higher level than for older age groups because children with bilateral and symmetric refractive errors of this and lesser magnitudes typically do not have functional improvement in visual behavior as a result of correction; as a result they are unlikely to wear their glasses. In addition, such refractive errors, when bilateral and symmetric, rarely cause significant bilateral ametropic amblyopia. The false-negative cases that do occur can be captured at later ages, as recommended by guidelines of the American Academy of Pediatrics, through either repeated objective (ie, instrument based) screening methods or during subjective acuity testing with minimal loss in function.

Table 1. Amblyopia risk factors targeted with automated preschool vision screening

	Refractive risk factor targets[a]			
Age, months	Astigmatism	Hyperopia	Anisometropia	Myopia
12-30	>2.0 D	>4.5 D	>2.5 D	>−3.5 D
31-48	>2.0 D	>4.0 D	>2.0 D	>−3.0 D
>48	>1.5 D	>3.5 D	>1.5 D	>−1.5 D
	Nonrefractive amblyopia risk factor targets[b]			
All ages	Manifest strabismus >8 PD in primary position Media opacity >1 mm			

D, diopters; *PD*, prism diopters.
[a]Additional reporting of sensitivity to detect greater-magnitude refractive errors is encouraged.
[b]For all ages.

2. Detection of Amblyopia Risk Factors Early in Preschool Children (Age Group: 31-48 Months)

For older children who remain unable to have visual acuity assessed directly, the detection of lower magnitude amblyopia risk factors becomes more important, although symmetric bilateral moderate-magnitude astigmatic and hypermetropic refractive error probably remains unnecessary to detect or treat. Recommended targets are as follows: astigmatism >2.0 D, hyperopia >4.0 D, and anisometropia >2.0 D. Refractive amblyopia risk factors that persist toward the end of this age range are less likely to spontaneously resolve[3] and are more likely to be associated with amblyopia. The detection of higher magnitude anisometropia (>3.0 D) should be highly sensitive for this age group because it is nearly always associated with amblyopia that continues to deepen over time.[10]

3. Detection of Amblyopia Risk Factors in Late Preschool and Kindergarten Children (Age Group: 49-72 Months)

For children aged 49-72 months, amblyopia risk factors for astigmatism, hypermetropia, and anisometropia are unchanged from the original guidelines. In this age range, moderate-magnitude astigmatism begins to produce decreased visual function, and detection should probably occur during this time period. Detection of myopia begins to become important in this age range because children begin to pay more attention to distance targets, and thus myopia of ≥−1.5 D should be detectable.

4. Detection of Amblyopia Risk Factors in School-Aged Children (Age Group: >72 Months)

Most children older than 72 months of age are able to read a standard linear optotype eye chart and can be screened using this modality (see below).[5] Exceptions are appropriate for delayed children, those unable to read letters, children who are uncooperative with optotype-based visual acuity, and high-volume field screening. Further research will determine whether objective technologies have greater utility compared with optotype-based screening for

Table 2. Reporting guidelines for nonrefractive vision screening instruments

Report sensitivity and specificity to detect
1. Visual acuity <20/30
2. ≥3 lines intraocular visual acuity difference
3. Manifest strabismus

school-aged children.[20] The USPSTF has specifically endorsed the use of photoscreening modalities for the detection of amblyopia risk factors in the 3- to 5-year-old age group.[16]

5. Detection of Amblyopia and Decreased Visual Acuity Using Traditional (Optotype-Based) Screening

Traditional optotype recognition screening remains a viable option for cooperative patients who can read linear letters because it allows the direct detection of decreased visual acuity. Nonetheless, it is time-consuming and often difficult until children are well into their elementary school years. When such children are screened, detection of monocular visual acuity <20/30, as specified by joint American Academy of Pediatrics/AAPOS guidelines, should be the standard. The use of stereopsis testing in isolation remains poorly validated and is not considered here.

6. Detection of Amblyopia and Decreased Visual Acuity Using Instruments Other than Photoscreeners and Autorefractors

Because many children with ARFs never develop amblyopia, the development and validation of screening techniques that can detect children with amblyopia or strabismus directly would be a major advance (Table 2). The Pediatric Vision Scanner detects the absence of foveal fixation as a harbinger of strabismus and amblyopia and is potentially an example of one such instrument.[21,22] Electrophysiologic testing of acuity or foveation might have similar advantages.[23] Reporting results from these instruments using the 2003 reporting guidelines would be futile because these instruments are not designed to detect refractive error in the absence of a resultant decrease in visual acuity. Instead, results from testing of these and similar instruments should report sensitivity and specificity to detect manifest strabismus, and ≥3 lines of interocular acuity difference.

In conclusion, further advances in technology will invariably force a reassessment of the preferred means of detecting children who have amblyopia or other causes of decreased visual acuity. Similarly, advances in our knowledge regarding the natural history of refractive error in children, and risk factors for amblyopia development will also force a reassessment of these guidelines. We actively encourage continued research in these areas and look forward to further revision of these guidelines.

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